

Land Management Along the Lewis Creek

Ian Burgin

Steven Chester

Logan Duran

Lisa Gerstenberger

Gus Goodwin

Matt Johnson

Caitlin Littlefield

Middlebury College
Environmental Studies Senior Seminar
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Introduction

Humans have modified river landscapes for centuries. River dynamics and floodplains have been impacted by navigation infrastructure, revetments, agriculture and urbanization. Our attempt to control natural river meander for both agricultural and infrastructural needs has historically resulted in inadequate habitat for aquatic creatures, decreased biodiversity, eutrophication and avulsions, among other lost river services. **See Figure 1.**

In the case of Vermont, agriculture is often one of the motivating factors for altering a waterway. Likewise, however, agriculture has played a dominant role in defining both the physical and cultural landscapes of current-day Vermont. The legacy of a once vibrant and diverse agricultural economy exists today in the form of heavy government subsidies for the dairy industry. Since it was once the case that dairy farms were far-and-away the most popular farm types in the state, and since cultural perceptions of Vermonters are very much rooted in that era, dairy farming persists today.

The Lewis Creek is an example of a Vermont waterway adversely affected by agriculture, and the community surrounding the Lewis Creek is exemplary of one affected by cultural perceptions of farming. The replacement of natural riparian vegetation with row crops and livestock has had direct impacts on the geomorphology and water quality of the Lewis Creek.¹ While all farms must adhere to a set of best management practices, the priority placed on keeping farms in the state has resulted in degraded riparian conditions as compared to the natural state.

In an effort to update river management techniques, the Agency of Natural Resources Water Management Program has written and researched extensively on “river corridor” management. A river corridor “consists of the river channel, the banks on either side and the areas close to the river that carry flood water and accommodate the meander

¹ Amy Jansen and Alistair I. Robertson, “Relationships between Livestock Management and the Ecological Condition of Riparian Habitats along an Australian Floodplain River,” *The Journal of Applied Ecology*, Vol. 38, No. 1, (Feb., 2001), p 64.

pattern of the river.”² **See Figure 2.** Objectives of a river corridor are both socially and ecologically motivated. They include restoring balance to the stream channel, improving water quality and restoring aquatic and terrestrial habitat.³ Since, however, there are no policies mandating their use, river corridors remain philosophical tools. The Lewis Creek Association (LCA), a watershed advocacy group, is utilizing the framework that the river corridor concept provides, as well as community education, in attempts to implement river corridor planning on the Lewis Creek. Just how to go about getting a river corridor established, or more specifically, how to go about meeting the ecological needs of the corridor without sacrificing agriculture, forms the bulk of this report.

Agricultural land use within the Lewis Creek watershed can be explained numerically as follows: The total area of the watershed is 51,124 acres (80 square miles) or roughly 6 times the size of the town of Middlebury. Thirty-three percent of the watershed is classified as ‘prime soils’ by the United States Geological Survey and 71% of the watershed agricultural lands are contained within them. According to data provided by the Vermont Center for Geographic Information, agricultural land uses account for roughly 29% of the watershed. **See Figure 3.**

The total area of the river corridor is 3,683 acres or about 25% of the entire watershed. Five percent of all agricultural lands lie within the river corridor. Thus, we can see from the get-go that the amount of farmland that would need to be taken out of production or otherwise altered to accommodate a river corridor is relatively small. In keeping with the methodology of the LCA, our report addresses a single section, or reach, of the waterway. Within our reach, which has a total area of 187.09 acres and occurs between Markers M19 and M22, there are 52.6 acres of agricultural land within the corridor (roughly 28%). Thus, the percentage of agricultural land that is subsumed by a theoretical river corridor is higher in this reach than in the watershed as a whole. **See Figure 4.**

² “River Corridor Protection and Management: Fact Sheet #1”

http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf, (VTDEC River Management Program, 2005a)

³ Lewis Creek Starksboro River Corridor Plan Steering Committee. “River Corridor Management Plan (Draft) Lewis Creek: Starksboro Valley Reaches M19-M22,” February, 2006.

Our partnership with the LCA was created so that we could consider what might be required in terms of agricultural land-use changes in a corridor that recognizes the river as a dynamic system. We began by identifying a set of dual goals that reflect the aims of the LCA: The overarching goals of this project are to improve the health of the Lewis Creek and to improve the economy of farming landowners in the Lewis Creek watershed. We choose to first look at policy as a means of achieving those goals, though we conclude that current policy is an inadequate pathway. Next we look at different agriculture types as a means for achieving the goals. Lastly, we provide a case study of willow farming illustrating our vision of alternative agriculture implementation.

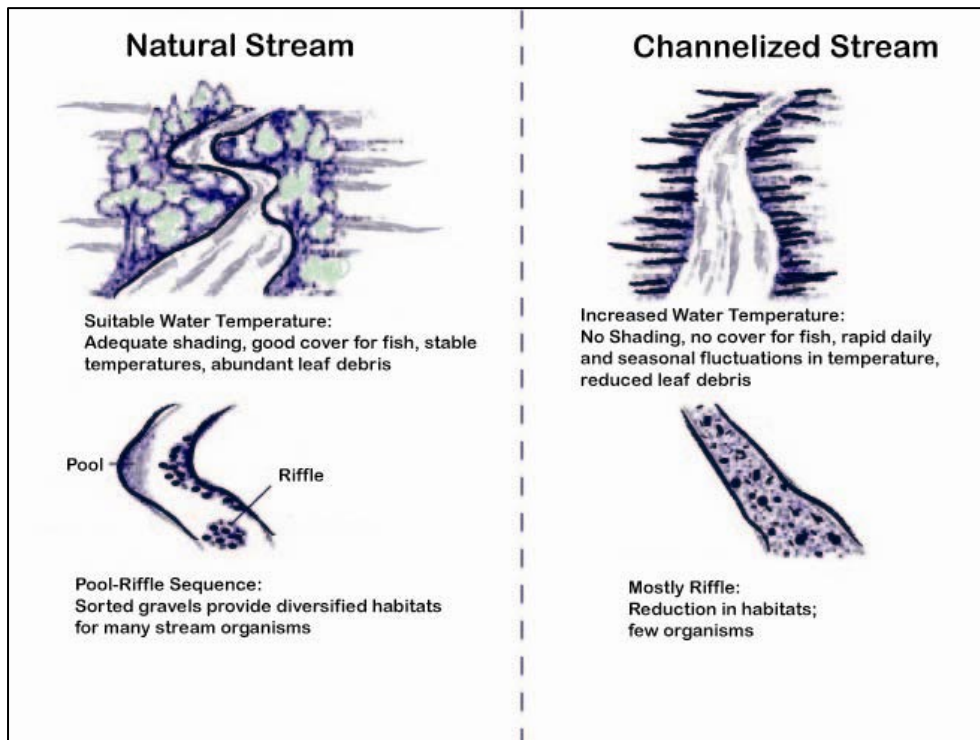


Figure 1: Natural versus channelized stream

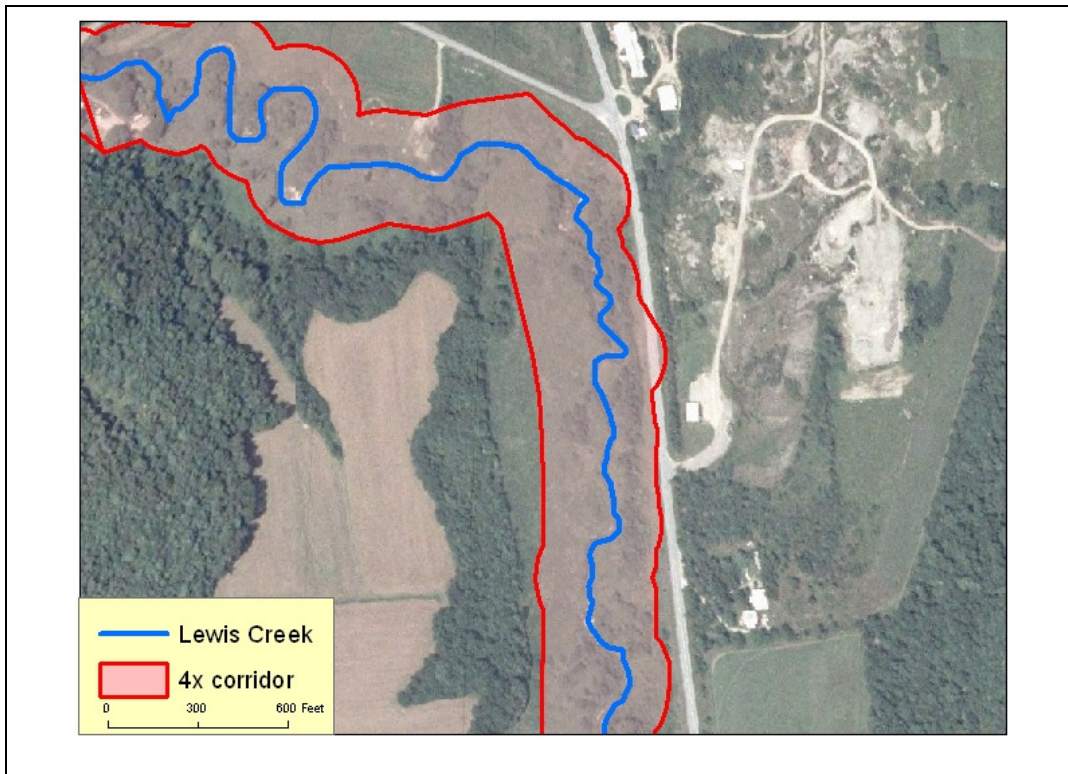


Figure 2: Example of Lewis Creek corridor delineation

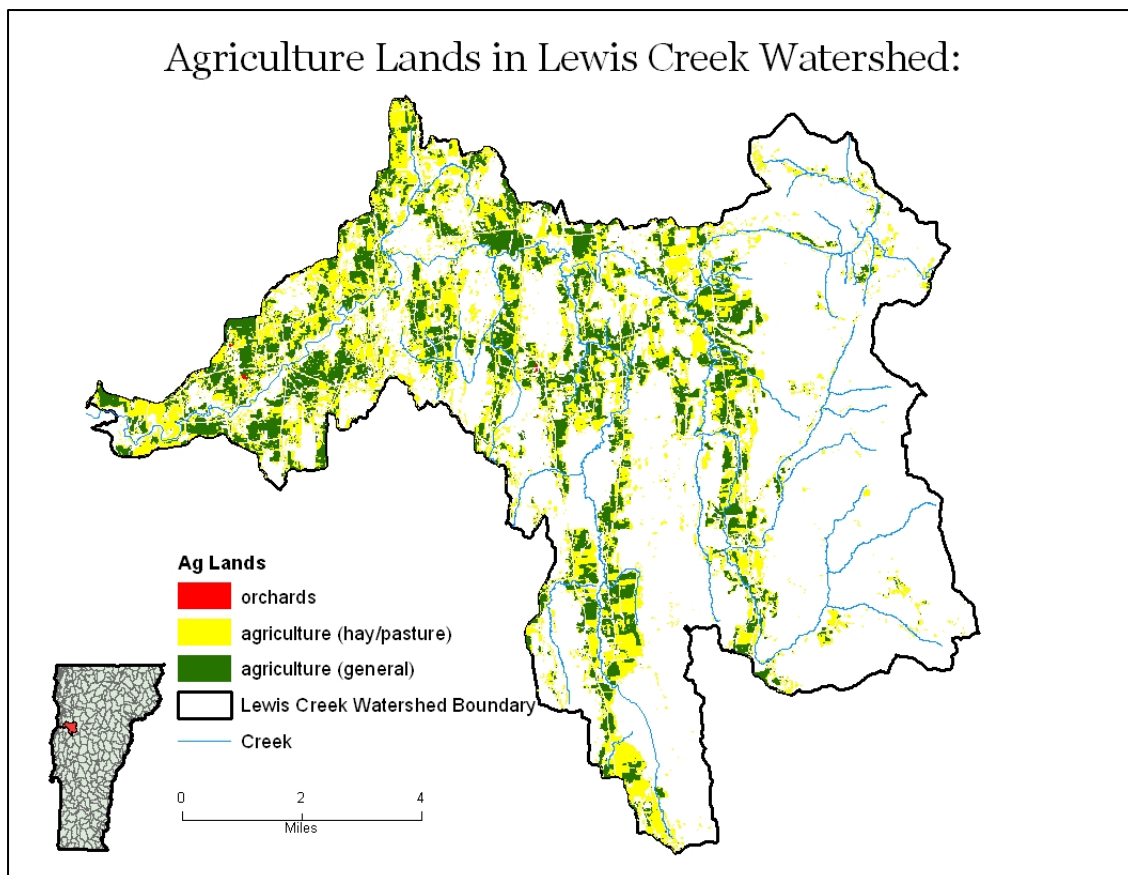


Figure 3: Agriculture Lands in Lewis Creek

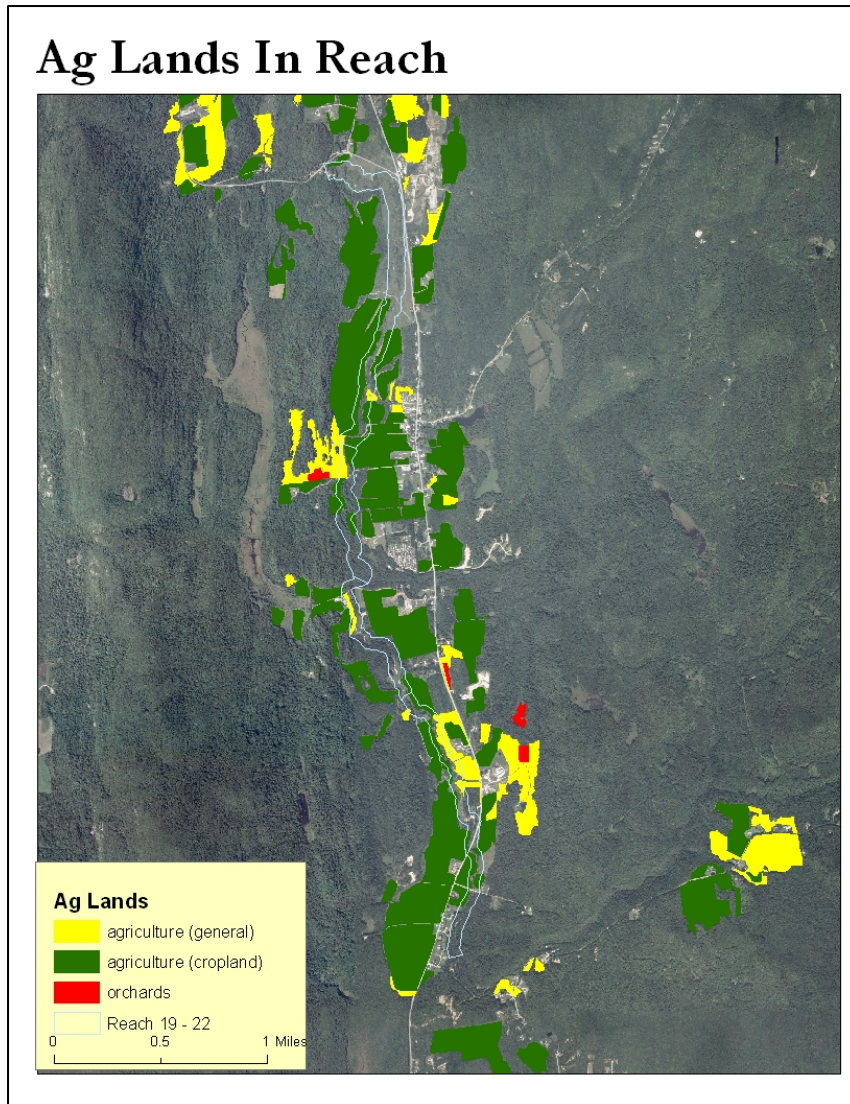


Figure 4: Agricultural lands in reach M19 – M22

Policy

Existing Policy

Ideally, to achieve ecological goals, land within the river corridor would not have agriculture or development. One efficient method of creating this sort of protected corridor would be to use regulation that requires corridor protection, though today such regulation does not exist in Vermont. Within federal, state and local policy in Vermont, there are gaps in protection for full river corridors. State and Federal laws regulate practices in the portions of the river corridors closest to the river—examples include manure application, following

pesticide application labels, acceptable zones for annual tillage and livestock access. Outside of the regulated area, but still within the river corridor there are areas that are not governed for such practices as cultivation and nutrient applications which prohibit the natural vegetation and ecosystem to become re-established.⁴ Incentives and regulations both play important roles in maximizing participation in environmentally-oriented plans. Thus, regulations, policies and programs that provide incentives for certain types of land use in the river corridor may be useful. This policy review will highlight existing regulations and programs regarding land use in the river corridor as well as illuminate current gaps in the policies.

We found it useful when thinking about existing policies, to separate policies providing regulations from those providing incentives. The regulatory policies in Vermont include (a) the Accepted Agricultural Practices Rule, (b) the Large Farm Operations Rule and the (c) Medium Farm Operations Rule. Policies and programs that provide incentives for land-use changes include the following five programs: (a) the Conservation Reserve Enhancement Program (CREP), (b) the Conservation Reserve Program (CRP), (c) the Vermont Agricultural Buffer Program (VABP), (d) the Environmental Quality Incentives Program (EQIP) and (e) the Wildlife Habitat Incentives Program (WHIP). A variety of local, state and federal-level funding sources support these programs, including the Vermont Agency of Agriculture, Food and Markets; the Vermont Department of Fish and Wildlife; the US Department of Agriculture; and Addison County Riverwatch. Portions of the Lewis Creek watershed qualify for enrollment in each of these programs.

Regulatory Policy

Vermont's Clean and Clear program supports existing Agency of Agriculture programs that create limited riparian buffers: the Accepted Agricultural Practices Rule, the Large Farm Operations Rule and the Medium Farm Operations Rule. The Accepted Agricultural Practices Rule, which applies to all types of farms, requires various setback

⁴ L. Hanrahan, Vermont Agency of Agriculture, Montpelier, VT, Personal communication with Lisa Gerstenberger (2007).

distances for specific aspects of farm operations.⁵ The Large Farm Operation Rule requires 25-foot buffers around waterways that run through croplands on large farms, large being defined by the number of animals kept on the land.⁶ In March of 2008 the Vermont Medium Farm Operations Rule will come into effect, requiring medium-sized animal farms to create 25-foot buffers around waterways as well.⁷ These buffers prohibit tilling and manure application but allow annual harvesting and some fertilization, depending on soil test results. Free technical support concerning implementation of water-quality control such as these measures is available to farmers through the Agency of Agriculture's Agricultural Engineering Program and Agricultural Resources Specialist Program.⁸

Incentive Programs

In order to encourage landowners to extend riparian buffer zones beyond the required distances of 10 feet or 25 feet (depending on the land use) financial incentives may be required. There appear to be various advantages to the existing incentive programs listed above. The first three programs – CRP, CREP and VABP – aim to manage nutrients entering waterways from dairy farms, specifically targeting phosphorous and nitrogen. CRP, which is federally funded, rents agricultural land near waterways on the condition that the farmer removes that land from production.⁹ The state- and federally-funded CREP program doubles the rental rate that CRP would pay *and* adds an extra financial incentive.¹⁰ Like CRP and CREP, the state-funded VABP pays rent for land near waterways, but unlike the other

⁵ Division of Agricultural Resource Management and Environmental Stewardship, "Large Farms Operations Rule." (Montpelier, VT: Vermont Agency of Agriculture, 2007). Accessed 7 Nov. 2007, <<http://www.vermontagriculture.com/ARMES/awq/documents/DraftLFORules.pdf>>.

⁶ Division of Agricultural Resource Management and Environmental Stewardship, "Large Farms Operations Rule." (Montpelier, VT: Vermont Agency of Agriculture, 2007). Accessed 7 Nov. 2007, <<http://www.vermontagriculture.com/ARMES/awq/documents/DraftLFORules.pdf>>.

⁷ Division of Agricultural Resource Management and Environmental Stewardship, "Medium Farm Operations Rule." (Montpelier, VT: Vermont Agency of Agriculture, 2007). Accessed 9 Nov. 2007, <<http://www.vermontagriculture.com/ARMES/awq/MFO.html>>.

⁸ Division of Agricultural Resource Management and Environmental Stewardship, "Available Resources." (Montpelier, VT: Vermont Agency of Agriculture, 2007). Accessed 7 Nov. 2007, <http://www.vermontagriculture.com/ARMES/awq/Available_Resources.htm>.

⁹ Vermont Natural Resources Conservation Service, "Conservation Reserve Program." (United States Department of Agriculture). Accessed 22 Oct. 2007, <<http://www.vt.nrcs.usda.gov/programs/CRP/>>.

¹⁰ Water Quality Division, "Vermont CREP Process," 2 Nov. 2004 Draft. (Waterbury, VT: Vermont Department of Environmental Conservation, 2004). Accessed 17 Oct. 2007, <http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_crep-process.pdf>.

two programs, allows some hay harvesting on enrolled land.¹¹ Because VABP has been given a trial period which will conclude in 2011, we will not explain it in detail here.¹² A farmer may enroll a particular piece of land in only one of these three programs at a time.

Farmers with lands planted with an agricultural commodity in the river corridor may profit most by enrolling land in the CREP program, as it pays an incentive sum in addition to rental money.¹³ In order to qualify for enrollment in CREP, land must border a non-ephemeral waterway with evidence of degradation in quality.¹⁴ The farmer must currently use the land for agricultural purposes where a land-use change would improve water quality, as determined by the Natural Resource Conservation Service (NRCS). NRCS determines buffer widths to be enrolled in CREP based on estimations of what would most improve water quality. This determination accounts for factors such as stream channel stability, slope and soil type. Typically, the buffer width is 2 or 3 channel widths on either side of the meander centerline, with a maximum belt width of 100 feet. Landowners may not pasture or harvest crops on land enrolled in CREP. CREP supplies funds to help farmers construct water systems, fencing and livestock crossings. A combination of funding from the federal and state governments as well as The Nature Conservancy support CREP. Enrolled landowners may receive rent payments for up to 30 years if they allow NRCS to plant trees in the riparian buffer. **See Box 1.**

¹¹ L. Hanrahan, Vermont Agency of Agriculture, Montpelier, VT, Personal communication with Lisa Gerstenberger (2007).

¹² L. Hanrahan, Vermont Agency of Agriculture, Montpelier, VT, Personal communication with Lisa Gerstenberger (2007).

¹³ L. Hanrahan, Vermont Agency of Agriculture, Montpelier, VT, Personal communication with Lisa Gerstenberger (2007).

¹⁴ As of 2004, this reach of the Lewis Creek is listed as polluted with *E. coli* from the lower covered bridge upstream to the footbridge, a distance of 12.3 miles. Water Quality Division "Impaired Waters Listed Due to Agricultural Runoff." (Waterbury, VT: Vermont Department of Environmental Conservation, 2004).

Box 1: Details of CREP payments

Currently Vermont's CREP funding is not being used in its entirety. As a result, qualified applicants are usually accepted and funds are readily available for agricultural lands within the Lewis Creek corridor. The amount of money that a farmer receives for enrolling land depends on a number of factors: the soil classification, the number of years in the last 6 that they have row cropped or hayed the land, the county in which the farm lies, whether the farmer chooses to enroll in the 15-year or 30-year contract and the amount of buffer reparation the farmer allows, such as planting trees. **See Appendix A.**¹⁵ Generally, the incentive payment and annual rental rates are calculated as demonstrated below.

See <http://www.vermontagriculture.com/ARMES/CREPwebsite/Incentives/Incentives.htm> for full details.

total incentive payment = \$/acre according to the land use prior to the contract * contract length *
number of acres enrolled

total rental payment/ year = \$/acre according to the soil type and county * 2 * number of acres enrolled

total payment during contract = total incentive payment + (total rental payment/year * number of years enrolled)

An upfront incentive payment for a farm in the Lewis Creek entering a 30-year contract would be roughly \$2,055/acre, assuming that the farmer has harvested an annual crop for at least 4 of the last 6 years. A typical rental payment per acre would be \$202/acre for Prime (b) soil type (which the majority of the agricultural lands in the M19 – M22 corridor are). Over the course of 30 years, this would total \$6,060/acre in rental payments, amounting to \$8,115/acre in rental and incentive payments over the 30-year period.

	\$/acre	\$/agricultural lands in corridor
CREP enrollment for 30 years	8,115	2,856,480
Hay production for 30 years	4,920	1,730,000
Corn production for 30 years	14,820	5,220,000

Table 1: Profits from different land uses

If all 352 acres of agricultural lands in the M19 - M22 corridor were enrolled in 30-year CREP contracts, they would receive a total of about \$2,856,480. This calculation is based on the rental payment rubric for Addison County for 2005 and the generalized soil type map produced by the USGS.¹⁶ If we assume that all of the agricultural land in the corridor grows hay, alfalfa or corn, rather than enrolling in CREP, it will bring roughly \$1,730,000 - \$5,220,000 in profits over the course of those 30 years (based on Vermont yield averages from the Vermont Agency of Agriculture, Food and Markets from 2001).¹⁷ Given that a farmer must rotate crops and thus typically cultivates a mixture of hay, corn and alfalfa fields, these calculations demonstrate that CREP has the potential to be financially competitive. **See Table 1.**

¹⁵ K. Peterson, Vermont Offices for the Farm Service Agency, Colchester, VT, Personal communication with Lisa Gerstenberger (2007).

¹⁶ K. Peterson, Vermont Offices for the Farm Service Agency, Colchester, VT, Personal communication with Lisa Gerstenberger (2007).

¹⁷ Based on Vermont yield averages of \$494/acre for field corn, \$278/acre for alfalfa and \$164/acre for hay. National Agricultural Statistics Service, "Vermont Reports and Statistics." (United States Department of Agriculture). Accessed 16 Nov. 2007, <http://www.nass.usda.gov/Statistics_by_State/Vermont/index.asp>.

Landowners interested in habitat restoration may enroll in WHIP or EQIP – incentive programs which share costs that landowners incur due to restoration efforts. EQIP gives technical and cost-share assistance to farmers and ranchers interested in reducing erosion, reducing runoff, conserving ground and surface waters and conserving habitat.¹⁸ WHIP supports buffer restoration projects as well as non-buffer land projects. Through WHIP, the USDA funds up to 75% of the cost of restoring fish and wildlife habitat.¹⁹ The Lake Champlain Basin Program (LCBP) is an additional resource, working in partnership with local communities on such projects as restoring wetlands and waterways using techniques including plugging old agricultural ditches, constructing fences around waterways to keep animals away, planting riparian vegetation, controlling invasive species, restoring native vegetation and constructing stream crossings for livestock.²⁰

Evaluation of Regulatory and Incentive Programs

The state and federal regulations discussed apply today only to livestock farms, leaving a policy gap that could be filled by state or federal regulations addressing setback requirements for other types of land uses, such as vegetable and fruit farms or new building construction. Ideally, the regulation of activities that cause erosion, runoff and stream channelization would apply to all land uses. They would establish uniform riparian zone treatment and protection, rather than the patchwork protection provided by regulations that exist today.

Efforts to fill gaps left by regulation should begin by encouraging landowners to take advantage of existing incentive programs. In the case of the Lewis Creek reach M19-M22, all land with the corridor qualifies for at least one of the programs listed, although the programs themselves are not specifically targeted at the river corridor. For farmers who qualify, CREP is clearly the best option because it pays the farmer more than CRP, and the state government is currently phasing out VABP. Non-farmers may participate in WHIP, but not

¹⁸ Vermont Natural Resources Conservation Service, "Vermont 2008 EQIP Information." (United States Department of Agriculture). Accessed 5 Nov. 2007, <<http://www.vt.nrcs.usda.gov/programs/eqip/>>.

¹⁹ Vermont Natural Resources Conservation Service, "Wildlife Habitat Incentive Program (WHIP)." (United States Department of Agriculture) Accessed 7 Nov. 2007, <<http://www.nrcs.usda.gov/programs/whip/>>.

²⁰ Lake Champlain Basin Program, "Program Partners," (Grand Isle, VT: Lake Champlain Basin Program). Accessed 22 Oct. 2007, <<http://www.LCB.org/partners.htm>>.

CREP, CRP, VABP or EQIP. WHIP and EQIP may be attractive to conservation-minded landowners, but they only provide restoration cost assistance.

Adoption of New Regulatory Policies and Incentive Programs

Another option for the LCA would be to advocate for increased regulations and/or new incentive programs targeted at river corridor protection and restoration, which may reduce runoff and erosion into the Lewis Creek. We recognize that for strategic reasons, the LCA has chosen not to engage in activity in the policy arena. However, this option is open to other individuals whose interests are aligned with LCA's in a desire to promote water quality and river corridor conservation in the Lewis Creek watershed. Thus, interested individuals might press the state to create a plan to control non-point runoff. In fact, every state is mandated to do this by the Clean Water Act—to date, however, no state has done so.²¹

²¹ B. Babbitt. Cities in the Wilderness. Washington: Island P, 2005. 1-200.

Finding Solutions: Alternative Agricultures

Setting the Stage

Although programs like CREP may be able to compensate farmers who take agricultural land within the river corridor out of production, they do not seem attractive enough to obtain the participation necessary to protect the entire river corridor. While in theory these programs have the potential to accomplish the broad goals outlined earlier—i.e. establishing a healthy creek and an economically viable community—as written now they are not end-all solutions. A successful approach to achieving environmental protection that does not come at the cost of community well-being may involve programs like CREP, but will also need to pursue other pathways in order to accommodate the variety of situations found in the watershed. One promising pathway is alternative agriculture.

Before discussing the different alternative agriculture types and their applications on the farm, it may be useful to touch briefly upon the semantics associated with the term “alternative agriculture.” First, it is important to acknowledge the difference between an alternative agriculture and an alternative *to* agriculture. Alternative agricultures are those which rely on crops or cultivation practices that differ from those of conventional agricultures (conventional agricultures being dairy and attendant row crops, like corn, in our reach). Alternative agricultures include crops such as vegetables, meat, tubers, pulp and fiber, as well as practices like no-till or organic cultivation. Conversely, alternatives *to* agriculture can take nearly any form, including sub-division and housing development, converting the farm into a bed and breakfast, or outright ceasing production on farm land. Listing and evaluating all of the various alternatives to agriculture that could be considered in our reach would be unduly time-intensive and irrelevant. Given the goals of this project, we will only consider alternative agricultures.

Even when considering only alternative agricultures, it would be superfluous to list and evaluate every possibility. After all, much of the success of an alternative agriculture depends on the personal interests of the farmer, his equipment, land quantity and quality, proximity to markets and other particulars. Organic rutabaga farming, while profitable for farmer A, may not be desirable for farmer B, if only because he doesn’t have an interest in rutabagas

or lacks either the equipment necessary or connection to a local market. We have therefore chosen to identify a *process* for finding alternative agricultures that meets the goals of stream health and economic viability. We hope that this process may identify particular alternative agricultures that are well-suited for adoption in our reach.

There is *no best* alternative agriculture for the watershed, or reach, or for any individual property. There may always be a better alternative and, perhaps more importantly, there may always be a better way to cultivate and sell a farm product. By identifying a process, we leave open the possibility of finding alternative agricultures in the future that are better than current forms of production. A process, rather than a list, has a wide range of applicability, is less vulnerable to shifting economic conditions, is more open to public discussion and we expect it will ultimately lead to more optimal solutions.

Initial Land Management Decisions

Having established clear goals and existing policy options, we may begin the process of selecting an alternative agriculture. The wide-spread adoption of alternative agricultures in the river corridor is not the target goal; it is a means of achieving our goals. In order for alternative agricultures to function as the means to the end of a protected river corridor, they must not only effectively reduce the amount of land needed under cultivation or have a lesser degree of environmental impact, but also be adopted by specific individuals.

This last part is perhaps the greatest challenge of the project. For example, if the LCA was pushing for the goal of converting 25% of the agriculture in the watershed to alternative agricultures, they would be able to target landowners who are ideal candidates. If a landowner did not want to cooperate, the LCA could simply move on to someone else. This is not the case for river corridor management. The success of implementing alternative agricultures to improve the corridor will depend largely upon the cooperation and enthusiasm of all individual landowners within the corridor and the viability of the alternative agricultures available to them.

Each landowner in the reach is likely to have different financial security and a different land ethic; conversations with the landowner may have a variety of outcomes. By recognizing these differences, we prepare ourselves to confront a diverse range of potential outcomes that may not always be consistent with our river corridor management goals.

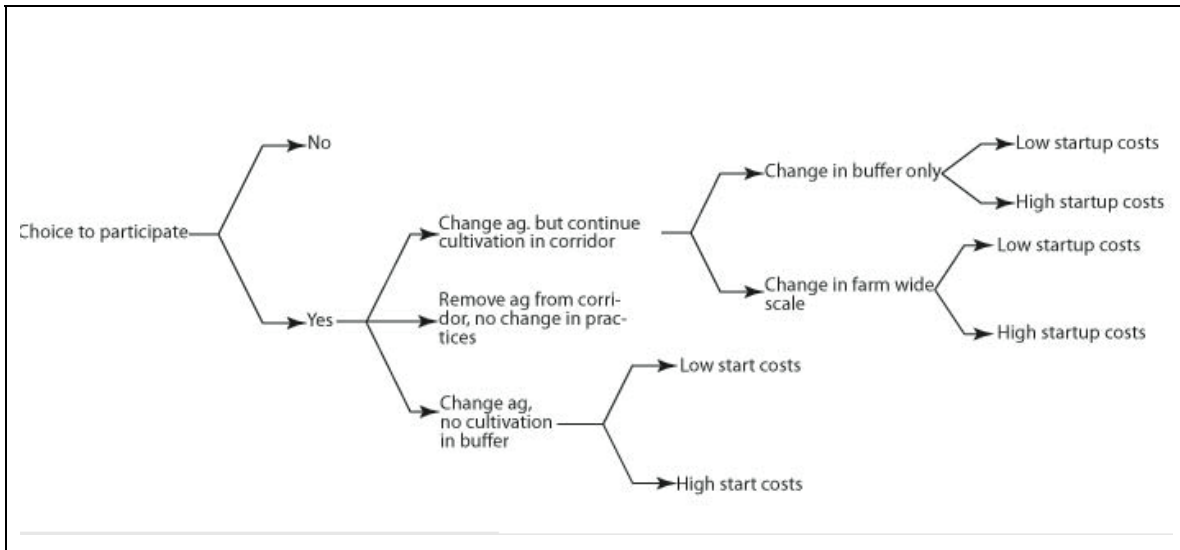


Figure 5: River corridor land-use decision tree.

In Figure 5 we represent the various land-use decisions that are relevant to river corridor management. The decision of whether or not to maintain agriculture in the corridor is the primary dividing point for a participating farmer. Solutions in which agriculture remains in the corridor will be different from those in which it does not. Consider the following two scenarios.

Scenario 1: *Alternative agriculture to improve the river corridor.* Suppose we have a farmer who is sympathetic to the need for improved riparian protection, but is unable or unwilling to stop cultivating land within the river corridor. He might be interested in altering his practices just in the corridor. In this example, the role of an alternative agriculture is to improve the quality of the river corridor to some extent while still providing economic benefit to the farmer. An ideal alternative agriculture for this scenario is one that is environmentally friendly (refer to section on “Choosing an Environmentally Friendly Crop”, p. 15) and has low startup costs and management efforts because only a small section of the farm would be changed. High-value crops or value-added crops may be even more desirable. A few possibilities may be tree products like Christmas trees, brambles like raspberries—the fruits of which could be sold as whole fruit or as value-added products like jams or jellies—or plants that produce woody biomass to be used as fuel.

Scenario 2: *Removing agriculture from the corridor.* Consider a farmer who is interested in converting his entire farm to an alternative agriculture. The role of an alternative agriculture in this scenario is to be profitable enough that the farmer can remove agriculture from the river corridor and cultivate only the land outside of it. Not surprisingly, the characteristics of an ideal alternative differ greatly from those of Scenario 1. Assuming the farmer will voluntarily cease to cultivate the river corridor, the alternative does not necessarily *need* to be more environmentally friendly—though this would certainly be ideal. The most important trait of alternative agricultures for this scenario is that they must be much more profitable than the current practices; they are more likely to have higher startup costs and management needs than the alternative agricultures in Scenario 1. Examples could include a transition to certified organic practices, diversified vegetable farming, or niche-market crops.

This decision-making approach highlights the importance of considering the role that agriculture may play within the river corridor in accomplishing the established goals of this project. The lack of policy makes Scenario 1 a very real possibility in a variety of situations; it means that currently a farmer is not required in any way to pursue alternative agricultures in cooperation with the LCA's river corridor management plan. Secondly, it means that even if a farmer successfully transitions to an alternative agriculture that is profitable enough that he no longer needs to cultivate land within the river corridor to make a profit, there is nothing to prohibit him from continuing to cultivate in the corridor.

Although the persistence of agriculture in the river corridor certainly undermines the success of the goal to protect and restore Lewis Creek, it seems possible that implementing particular alternative agricultures could improve conditions to some extent. The success of any alternative agriculture will be determined by its environmental and economic viability.

Choosing an Environmentally Friendly Crop

Evaluating the environmental impacts of alternative agriculture poses many significant problems. First, by definition, nearly any form of agriculture can be considered an alternative and a list of alternative agriculture practices could potentially be endless. Second, the environmental impacts of any given alternative (e.g. organic farming) can vary

tremendously from location to location depending on site conditions like slope, soil type, or proximity to surface water as well as the specific nature, timing and intensity of practices applied by the landowner. This volume and variability of alternatives makes it nearly impossible to identify the “best” alternative and difficult to rank alternatives.

A framework for evaluating the environmental impacts of alternatives avoids some of the problems described above. With the guidance from Dave Braun at Stone Environmental Inc., the following framework was constructed to assess the relative value of an agricultural alternative based on how its structure and function compare to the structure and function of the ideal situation.²² The framework is this: 1) Goals must be identified and values assigned to the resource in question; 2) Establish the baseline—or the ideal situation which would accomplish these goals; 3) Assess to what extent any given alternative resembles the structure or function of the ideal situation.

Step 1: *Identify management goals and select criteria.* The resource is the Lewis Creek. The values associated with it are drainage, sediment transport, irrigation, habitat, etc. The LCA may choose a few of the values associated with the Lewis Creek as those it wishes to focus on. Our interpretation of the 2006 Draft River Corridor Management Plan²³ leads us to believe that the LCA is most concerned with sediment transport and aquatic habitat.

Step 2: *Establish the baseline.* The natural condition for stream banks in Vermont is a riparian forest, and its structure and function are such that it accomplishes the goals and supports the values outlined in Step 1. In this case, the most desirable benefits are derived from the forest’s extensive root network. The roots help minimize soil loss by stabilizing stream banks, as well as providing structure in the soil through root penetration. Anyone who has pulled weeds before is aware of the extent to which the root system of a single plant can retain soil. The diversity of plants within the forest can help determine the nature of the root network. Trees, both shallow and deep rooting species, provide large, sturdy roots as well as smaller, fibrous roots. Forests are also less susceptible to the harmful impacts of rain

²² D. Braun, Stone Environmental Inc, Montpelier, VT, Personal communication with Gus Goodwin (2007).

²³ Lewis Creek Association Watershed Planning, “River Corridor Plan: Lewis Creek M19 to M22, Starksboro Valley”. Accessed September 2007, <<http://www.lewiscreek.org/M1922.htm>>.

falling directly upon bare soil because the dense vegetation canopy and the organic litter and duff which cover the ground intercept rainfall. In addition to maintaining the structure of the stream banks, riparian forests also have a direct effect upon the water quality of the stream. They have been demonstrated to act as filters for ground and surface water, reducing the nutrients and sediment deposited in streams by runoff through slowing water movement and biomass accumulation. Riparian forests also can influence the quality of the stream as habitat by providing shade and woody debris.

Step 3: *Assess the extent to which the traits of an agricultural system resemble those associated with the riparian forest.* Let us consider growing Christmas trees in the riparian zone as an example. Tree farming seems logical because the crop (trees) resembles the components of the riparian forest. However, there are several questions raised by this assumption. How does the root density and over-all structure of the root network of a tree farm compare to that of a riparian forest? Will the tree farm provide adequate function? If not, what structures are missing that could feasibly be added? What natural processes, if any, does harvesting the crop resemble?

Grouping agricultural systems with respect to their shared traits may allow the assessment to go more quickly. A break-down of groups may look like this: trees and shrubs, perennial vegetation, conventional row crops and livestock. After a target group is identified, the options may be grouped again. So for the group trees and shrubs, subgroups like tree plantations, orchards, shrubs which are harvested whole, or berry producing shrubs could be identified. Next, subgroups could be identified to species level and eventually down to the level which addresses management practices and site specific constraints.

Economic Viability

Alternative agricultures must be profitable to be considered. It would be a vain effort to try and pitch the idea of an alternative agriculture to a farmer without being able to demonstrate its profitability. How then do we begin to think about the economic side of an alternative?

It would seem that the best way to go about demonstrating the superior money-making potential of alternative agricultures is with price per acre numbers. Showing that

Crop A fetches more than Crop B for a given acreage is an intuitive way of comparing different farm economies, especially given that we have already thought about alternative agriculture acreage when evaluating environmental impacts; some alternatives, in order to meet ecological goals, must require less land. Likewise, it would seem that price per acre would allow the farmer to easily compare his current potential income (from dairy) with the potential income of an alternative.

That said, we have determined that assigning worth to a crop with price per acre is *not* an effective way to go about promoting alternative agriculture in the watershed. Perhaps the best way to see the shortcomings of the price per acre approach is to provide an example. Below is a list of Vermont crops compiled with the input of local farmers Pete Johnson (Pete's Greens), Paul Stone (former secretary of Vermont Agriculture, Stonewood Farms) and Paul and Amy Lacinski (Sidehill Farm). All four farmers identified the following crops as those with the most market potential in Vermont.

Price/Acre			
Lamb	\$375	Cucumber	\$4,500
Cattle	\$4,000	Romaine Lettuce	\$7,000
Goats	\$420	Onions	\$6,700
Turkeys	\$900	Squash	\$4,000
Chicken	\$500	Sweet Potato	\$3,400
		White Potato	\$1,500
Broccoli	\$4,900	Soybeans	\$180
Carrots	\$6,500	Barley	\$400
Cauliflower	\$6,100	Oats	\$300
		Red Spring Wheat	\$170

Table 2: National Agricultural Statistics Service price per acre statistics

The numbers provided in **Table 2** were gathered from the National Agriculture Statistics Service (NASS) in the USDA.²⁴ They represent national averages for the year 2006. The USDA offers the *only* information on yearly crop price. Any discussion of numbers, therefore, barring extensive research, will be based on NASS statistics. NASS statistics are based on national markets. Herein lies the first shortcoming: national markets

²⁴ National Agriculture Statistics Service, "Crops and Plants Statistics Search." (United States Department of Agriculture). Accessed 2 Dec. 2007, <http://www.nass.usda.gov/QuickStats/indexbysubject.jsp?Pass_group=Crops+%26+Plants>.

are exactly those that Vermont alternative agriculture farmers would seek to avoid. After all, one of the current problems of dairy is that farmers compete with a number of large-scale western and Midwestern farms with greater growing potential.

According to Pete Johnson of Pete's Greens, often the reason that alternative agricultures in Vermont are successful in the first place is that they do *not* compete with national prices. The money that a farmer receives for a locally grown and locally sold crop is usually higher than the money he would receive if he were to sell that crop to a national market; locally sold crops do not require expensive transportation and/or may fetch a higher price simply because of the fact that they are grown nearby. A list of national averages of price per acre, therefore, may be less relevant than a list of Vermont prices, and especially less relevant than a list of local prices.

Another shortcoming of the national numbers is that few data are available, and newly emerging niche-market crops have no data at all. According to Paul Stone, a host of specialty crops such as bison, heirloom turkeys, dairy goats, organics etc. have growing potential in Vermont. The future of alternative agriculture may lie in exploring non-traditional food types. Such a trend is exemplified by organic farm statistics gathered over the past 13 years. The Northeast Organic Farming Association of Vermont reports three certified organic dairy farms in 1993 and 195 certified farms in 2007.²⁵ Moreover, the number of organic dairies doubled over the course of the past two years. A price per acre approach would leave out any discussion of these niche-market crops; there are no available price data.

Lastly, USDA price per acre numbers explain a number of large-scale western and Midwestern farms with specific practices that differ from small-scale Vermont farms. The price that one of these large-scale farms receives for a crop will surely differ, if only because of economies of scale, from the price that a smaller farm would receive.

²⁵ Northeast Organic Farming Association of Vermont, "2007 Statistics on Certified Organic Agriculture in Vermont." (Richmond, VT: Northeast Organic Farming Association). Accessed 2 Dec. 2007, <http://www.nofavt.org/pdfs/2007_year_end_stats.pdf>.

So if the USDA numbers are the only numbers available, and if they are not relevant, why not go about finding numbers from a more local source with more relevancy? As it turns out, doing so would be a nearly impossible task. Price per acre values of any kind are made less relevant by the fact that they don't take into account "farm particulars"—soil type, a farmer's equipment and his personal interests, for example. That is to say the amount of money a farmer stands to make on an alternative crop is contingent on his particular farming situation. According to Paul Stone, the needs of a farmer with some interest in starting an alternative agriculture include technical expertise, market research, sales, infrastructure, etc.—all of which must be tailored to the farmer's geographic location, equipment and know-how. Any price per acre statistics applicable to more than one farmer would do little to describe the money-making potential of a crop.

Upshot

The main conclusion of the alternative agriculture process is that an individual approach be taken with farmers in the watershed. Since the environmental impact and economic potential of an alternative agriculture varies from farmer to farmer, the best way to begin working on getting alternative agriculture in the corridor is on an individual basis.

Conclusions

In order to meet the ecological needs of the Lewis Creek without compromising the economies of farming landowners, we propose alternative agricultures. A discussion of policy reveals that CREP, while theoretically functional and attractive, does not get the kind of participation necessary to protect the entire river corridor because of farmers desire to retain all rights of control of their land. Farmers are often unaware of the benefits of CREP. We expect that increased awareness and transparency of the process will increase participation. Determining the ideal land-use changes for each property within the river corridor is difficult without more detailed information regarding the current land use, values of the landowners, soil types, etc. Thus, this analysis has created a process that may be applied to land within the corridor in order to select a land use that will promote improved stream health and economic viability.

The LCA (or some comparable organization) should work with farmers individually to assess their conservation goals, their farming interests, the suitability of their land for different crops and the viability of those crops given local and national markets. They should make decisions considering potential impacts of land uses within the corridor and outside of the corridor. They should consider whether they would qualify for incentive programs, such as CREP, WHIP or EQIP. The LCA may then direct them towards technical support for enrollment in, and implementation of, these programs.

Most importantly, we must use a proactive approach towards finding culturally sensitive solutions for ecological health of the Lewis Creek watershed. Changes must be tailored to the individual situations of each landowner and property in order to maximize success.

The Individual Approach: A Case Study in Willows

The following case study outlines the potential for an alternative agriculture within the corridor. A lack of strict policy prohibiting agricultural practices within the corridor encourages the use of the model outlined in previous sections of a case-by-case assessment of agricultural improvements and practices that could proceed within the corridor.

One of the unique aspects of our project is the opportunity to achieve specific ecological goals from the use of alternative agriculture within the corridor. Policy limitations and the need for voluntary adoption and adaptation of farming techniques in the corridor is a challenging scenario, but one that calls for innovative solutions. The continuation of agriculture in the corridor is likely, but the acceptance and implementation of an alternative agriculture is a possibility that does not threaten a farmer's economic livelihood while alleviating environmental stress on the ecosystem. This project has searched for solutions that can be implemented within the corridor. Throughout this report we have explained that we are not trying to identify the "best" alternative. We simply are trying to identify something that is significantly "better" than current management strategies. The following case study on willows is an example of an alternative agriculture that is "better" than current practices.

Striving for Riparian Forest Authenticity

If agriculture is to continue unabated in the corridor, alternative crops should closely mimic the natural condition of the banks of the Lewis Creek, as outlined in Step 3 of "Choosing an Environmentally Friendly Crop" (see page 17). In other words, an alternative agriculture must be evaluated based on how close it comes to achieving the ecological *authenticity* of a riparian forest.

Three key components reflected in a measure of authenticity are composition, structure and function. Composition describes what species exist in a system; structure describes how the characteristics of these components are manifest physically (e.g. how extensive are the root systems? how complete is the canopy?); function describes the way in which a system works (e.g. nutrient

cycling) and how it experiences and responds to internal and external processes (e.g. high water disturbance).²⁶

By definition, imposing an agriculture upon what would naturally be a riparian forest cannot achieve the precise composition of this natural ecosystem. But, as noted above, the optimal alternative agriculture—optimal in terms of ecological health while being economically viable—will most closely resemble the composition, structure and function of the natural riparian forest. Trade-offs are certainly inevitable: composition may be compromised by the imposition of a crop not found in the natural riparian forest, but that crop may achieve a critical function that a species of a riparian forest would serve. In Box 2 below, we describe the general structure and function of a riparian forest.

²⁶ N. Dudley, "Authenticity as a Means of Measuring Forest Quality," Biodiversity Letters Vol. 3, No. 1. (1996): 6-9.

Box 2. Riparian Forest Structure and Function

Without addressing the species present (i.e. composition), the following briefly describes the structure and function of a riparian forest. An authentic riparian forest would likely exhibit the structural characteristics of 1) a basal area larger than that of the upland forest; 2) many young plants resulting from high rates of reproduction and the ability of many species to propagate both asexually and by various dispersal mechanisms (as seen especially in poplar and willow); 3) greater aboveground biomass than belowground; and 4) spatial zonation running perpendicular to the flow of water, varying with topography and flood susceptibility.²⁷

Riparian forest species have adapted morphologically to stresses such as anoxic or unstable substrates caused by flooding. Such adaptations include: 1) root and stem aerenchyma (air spaces) that allow for oxygen diffusion; 2) stem buttressing; 3) root flexibility (e.g. as in poplars and willows); and 4) adventitious roots arising at 'abnormal times' and originating from 'abnormal' origins such as stems and branches (e.g. as in poplars, willows and birch).²⁸

These adaptations are critical to the survival of the specialized, disturbance-adapted plants of riparian communities—communities that typically exist within a matrix of less specialized and less frequently disturbed upland forests. Various life history strategies also enable the persistence of riparian forest species. A given species may be labeled, for instance, as 1) an invader, with a large number of colonizing propagules spread via wind and water; 2) an endurer, resprouting after breakage or burial due to, say, water inundation; or 3) a resister, withstanding various disturbances. An increase in physical heterogeneity due to natural disturbances like flooding can create distinct regeneration niches that facilitate coexistence of cogenetic species in addition to a broad range of genera.²⁹

This diversity is also reflected in the functions of riparian forests. Trees retain soil in extensive root systems and foliage decreases the impact of precipitation upon the soil. They can slow flowing water, decrease stream power and entrap materials. Woody debris from the plants also dissipates water energy, traps moving materials, forms habitats, changes micro-currents in such ways that influence erosive actions and retains water and thus materials for longer periods of time. Woody and leafy debris, organic detritus and dissolved organic matter may provide nourishment for aquatic organisms. The presence of plants—particularly trees—influences the microclimate of the stream banks as well: stream water temperature is strongly related to soil temperature; plant structure may decrease wind speed and block solar radiation; and evapotranspiration by plants impacts local water balance. Lastly, riparian forests may serve as ecological corridors—not to mention habitat—for wildlife and, though less beneficially, the movement of invasive species.³⁰

When envisioned as a buffer between the stream and other land uses, riparian forests can also function as filters for non-point sources of pollution, capturing sediments (including prime agricultural soils) and nutrients. These nutrients may be sequestered for long periods of time depending on the woodiness of the species present, and the extensiveness of their root systems. This is especially true in forests because transpiration may be very high, which leads to an increased mass flow of nutrients into biomass.³¹

²⁷ R. J. Naiman and H. Decamps, "The Ecology of Interfaces: Riparian Zones," *Annual Review of Ecology and Systematics* Vol. 28 (1997): 621-58.

²⁸ Naiman and Decamps, 621-58.

²⁹ Naiman and Decamps, 621-58.

³⁰ Naiman and Decamps, 621-58.

³¹ Naiman and Decamps, 621-58.

Evaluating Tree Crop Alternatives

In the absence of a complete elimination of agriculture from the corridor and a complete return to a natural riparian forest, the ecologically optimal alternative agriculture would most closely mimic the structure and function of a riparian forest described in Box 2. In the specific case of Lewis Creek, we hold the function of stream bank stabilization as the primary goal.

Trees, above all other crops, most closely resemble an authentic riparian forest. Specifically, each potential tree crop must be evaluated based on a comparison between its structure and function and that of a riparian forest (see the framework in “Choosing an Environmentally Friendly Crop”). Many circumstantial factors and nuanced variables need to be considered for each site, but the following elimination process may generally outline how decision-makers may arrive at the most desirable crop—by no means is the following an exhaustive investigation of options.

In the absence of a complete return to riparian forest, sustainable forestry may most closely mimic it. This sort of agriculture may be too protracted in time to be an economically feasible consideration. Consider another option: apple trees. This may be discarded because orchard trees tend to be placed too far apart to provide adequate substrate stabilization to avoid erosion. Next, consider poplar trees to be harvested for biomass (for heat and electricity production). Poplar cropping systems are usually grown on seven-year rotations.³² While achieving larger size and therefore providing more vertical structure and nutrient sequestration capacity, even this crop may have too protracted a harvesting process to be feasible.

Lastly, consider willow to be harvested for biomass. Willow may come closer than other alternatives to achieving the structure and function of the riparian forest while being an economically lucrative crop. Indeed, they have been consistently planted in riparian areas for stream bank stabilization (at costs far lower than riprap, for instance), yielding the immediate and long-term benefits of erosion control, earth reinforcement and mass stability of slopes, because they have extensive and often aboveground, arching root systems.³³ The majority of willow fine roots lie in the upper 20-30 cm of soil—where sediments are most likely to be washed away from runoff. Vertically,

³² G. A. Keoleian and T. A. Volk, "Renewable Energy from Willow Biomass Crops: Life Cycle Energy, Environmental and Economic Performance," *Critical Reviews in Plant Sciences* Vol. 24 (2005): 385-406.

³³ C.C. Watson, S. R. Abt and D. Derrick, "Willow posts bank stabilization," *Journal of the American Water Resources Association* Vol. 33, No. 2 (1997): 293-300.

the roots can extend down several meters, furthering the plant's ability to hold sediments (including prime agricultural soil) and nutrients, therefore limiting erosion.³⁴

We have identified stream bank stabilization as a primary goal in this evaluative process. But a strong alternative agriculture—and willow may certainly be one—will also achieve secondary goals like providing wildlife habitat and decreasing chemical pollution as compared to existing agriculture. An extensive literature review by Middlebury College faculty and students found that the net environmental impacts of converting fields to willow depend upon prior land use. The most common negative impacts of willow systems are soil erosion and chemical pollution, especially in the initial establishment phase. A conversion of row crop agriculture to willow generally results in the ecological betterment of the land—a positive impact. Conversion of hayfields is neutral or slightly negative, and a reclaiming of abandoned agricultural land with willow may have negative site and landscape impacts.³⁵ In the case of Lewis Creek, we are exploring alternatives to existing agriculture (e.g. corn row cropping), and because the area in question is a sensitive river corridor, a shift towards willow may very well have no negative environmental impacts. Nevertheless, the potential for soil erosion and chemical pollution associated with some willow crops must be addressed and may be partially mitigated by conservation tillage and cover cropping.³⁶

Willow grown for biomass is considerably less environmentally damaging than other crops for a variety of reasons, and may indeed result in positive environmental externalities. As opposed to a single-species monoculture, hybrids and mixtures of willow species are typically planted, thereby enhancing structural and functional diversity and reducing pest and disease impacts.³⁷ Particularly in areas where shrub land is already in decline, willow trees provide habitat for a wide-range of birds, as opposed to other non-woody crops.³⁸ Willow is harvested after leaf fall, meaning that the translocation of leaf, branch and stem nutrients to roots will have already occurred. This over-winter

³⁴ T. A. Volk, L. P. Abrahamson and E. H. White, "Biomass Power for Rural Development Technical Report: Root Dynamics in Willow Biomass Crops," No. DE-FC36-96GO10132, Prepared for the United States Department of Energy (2001).

³⁵ S. Fortin, K. Macfarlane, M. Lapin and M. Landis, "Environmental Impacts and Agronomic Methods of Short-Rotation Willow Cultivation: A Review of Published and Web-Based Literature," Prepared for Middlebury College Environmental Affairs (2007). Accessed 28 Oct. 2007, <<http://www.middlebury.edu/administration/enviro/initiatives/climate/Willow+Growing+Project.htm>>.

³⁶ Fortin et al.

³⁷ Volk et al., "Growing fuel," 411-18.

³⁸ P.J. Tharakan, T.A. Volk, C.A. Lindsey, L.P. Abrahamson and E.H. White, "Evaluating the impact of three incentive programs on the economics of cofiring willow biomass with coal in New York State," *Energy Policy* Vol. 33, No. 3 (2005): 337-47.

nutrient storage is critical for vigorous resprouting the following spring. The litter layer that develops further decreases the potential for soil erosion. With relatively little traffic on the soils where willows are planted—as compared to traditional row crops—soil compaction is minimized.

Lastly when biomass feedstock is used to displace fossil fuels in heat and electricity production, fewer air pollutants are emitted into the atmosphere. These include sulfur, trace metals and carbon dioxide which is contributing to climate change. Instead, fine-rooted perennial crops like willow enhance soil carbon storage.³⁹

Growing and Harvesting Willow for Biomass at Middlebury College

To understand the growth and harvesting methods associated with willow systems, consider the process that Middlebury College is undergoing. Just south of the Lewis Creek watershed the College has begun constructing a biomass plant with the objective of drawing its fuel needs for heating, cooling and electricity from a sustainable and local source. The biomass plant will require roughly 20,000 tons of wood chips per year. The College has explicitly recognized that the increase in demand for wood chips may stimulate help boost the local biofuel economy.⁴⁰

Drawing upon existing feasibility studies and test plots—particularly those of the SUNY College of Environmental Science and Forestry—the College itself planted in 2007 a 10-acre test plot of 30 different willow varieties at a density of approximately 6,000 willow whips per acre. After one year of growth, the plantings will be cut back to the base, or ‘coppiced,’ in order to encourage more lateral growth. The willows will then grow for another two years, gaining a height of roughly 20 feet.

They will be harvested—using standard corn harvesting equipment—in the fourth year and chipped for use in the biomass burner. The regrowth from the trees will then be harvested annually thereafter.⁴¹ Since the root system is allowed to develop during the first rotation, more biomass is allocated by each individual plant to the aboveground portion during later rotations. Yields may therefore be expected to increase up to 130% from first to second rotation. Furthermore, with

³⁹ Tharakan et al., 337-47; Volk et al., “Growing fuel,” 411-18.

⁴⁰ “New biomass facility to reduce greenhouse gases by almost 12,500 tons a year,” ed. S. Ray, 30 Sept. 2006, Public Affairs, Middlebury College. Accessed 31 Oct. 2007, <http://www.middlebury.edu/about/pubaff/news_releases/2006/news632951384540792349.htm>.

⁴¹ Fortin et al.

sound management practices, productivity of this crop can be maintained for many rotations—seven or more.⁴² The College intends to share lessons learned from this test-plot with local landowners and farmers in the hope that they may consider growing willows as a biofuel.⁴³

Economic Sustainability

Growing willow in the Lewis Creek corridor, as an alternative to the less environmentally sound agricultures in the corridor today, will help bring Vermont one step closer to being less dependent upon fossil fuels. Furthermore, the low energy density of biofuels like willow limits feasible transport distances, and its organic nature limits storage time. This results in a short supply chain, both spatially and temporally, and produces jobs. Modeling estimates show that 75 direct and indirect jobs may be created for every 4000 ha of willow biomass crop planted.⁴⁴ Economic and environmental benefits associated with deployment and use of the fuels may therefore be expected to accrue at a local scale.⁴⁵

While it is difficult to pinpoint prices that willow growers could expect, a report from the Vermont-based Biomass Energy Resource Center found that a price range of \$40 to \$64 per ton of bole (main trunk) chips may be expected, and \$30 to \$40 per ton of whole-tree chips.⁴⁶ Tharakan et al. found the pricing to be similar.⁴⁷ Considering site preparation, cultivation and harvesting, and all the human and physical capital associated with these processes, these researchers found the farm-gate price (the price for which the product is available at the farm) for willow biomass feedstock to be roughly \$2.46 GJ⁻¹ (compare this to \$1.23 GJ⁻¹ for coal). Each year, a willow grower may expect

⁴² T. A. Volk, T. Verwijst, P.J. Tharakan, L.P. Abrahamson and E.H. White, "Growing fuel: a sustainability assessment of willow biomass crops," Frontiers in Ecology and the Environment Vol. 2, No. 8 (2004): 411-18.

⁴³ Fortin et al.

⁴⁴ G.J. Proakis, J.J. Vasselli, E.H. Neuhauser and T.A. Volk, "Accelerating the commercialization of biomass energy generation within New York State," Proceedings of the Fourth Biomass Conference of the Americas, Biomass: A Growth Opportunity in Green Energy and Value-Added Products, Oakland, CA. 26-29 Aug. 1999: 1711-16.

⁴⁵ Volk et al., "Growing fuel," 411-18.

⁴⁶ A.R. Sherman, "The Vermont Wood Fuel Supply Study: An Examination of the Availability and Reliability of Wood Fuel for Biomass Energy in Vermont," Prepared for the Vermont Department of Forests, Parks and Recreation and the Vermont Department of Buildings and General Services. (Montpelier, VT: Biomass Energy Resource Center, 2007).

⁴⁷ Please see this article by Tharakan et al. for a complete discussion of assumptions and a further discussion on how increased grower profit may be realized by using policy such as the Conservation Reserve Program, upon which Vermont's Conservation Reserve Enhancement Program is based.

to harvest roughly 6.72 oven-dried-tons of willow per acre. If the gross energy value of an oven-dried-ton of willow is 17 GJ⁻¹ a grower may expect to earn \$281 per acre in a year.⁴⁸

Tharakan et al. have focused much of their research on ways in which programs like the Conservation Reserve Program (CRP)—an amendment of which provides for the harvest of biomass crops on 101,000 ha of CRP land throughout the nation—may help decrease production prices for willow growers and increase market demand.⁴⁹ As noted, the price per energy unit of coal is far lower than that of willow, which is leading to an over-provisioning of the fossil fuel energy base and a suppression of demand for cleaner energy sources like biomass. The negative externalities associated with fossil fuels like coal and the positive externalities associated with fuels like willow are not yet reflected in these prices, hence the differential in favor of fossil fuel.

Rent-paying programs like CRP could function as mechanisms to capture the benefits associated with biomass crops—as related to soil and water quality and wildlife habitat. This would therefore decrease the cost of willow production, leading to a lower farm-gate price (compensated for by CRP rent payments) and higher demand.⁵⁰ Even without considering programs like CRP that may bolster demand, we anticipate that the burgeoning demand for clean fuels in general—as evidenced by Middlebury College's new demand for wood chips and the exploration of other biofuel crops throughout Vermont like reed canary grass and sunflower for biodiesel feedstock—will only lead to more favorable prices for growers.⁵¹

⁴⁸ Tharakan et al., 337-47.

⁴⁹ E. Neuhauser and S. Edick, "Biomass Power for Rural Development: Comparative Business Structure Report," No. DE-FC36-96GO10132, Prepared for the United States Department of Energy (2001); Tharakan et al., 337-47.

⁵⁰ Tharakan et al., 337-47.

⁵¹ D.S. Powlson, A. B. Riche and I. Shield, "Biofuels and other approaches for decreasing fossil fuel emissions from agriculture." *Annals of Applied Biology* Vol. 146, No. 2 (2005): 193-201; N. White, "Vermont farmers could grow fuel for local consumption," *Addison Independent* 25 Oct. 2007: A17; N. White, Vermont Biofuels Association, Middlebury, VT. Personal communication with Logan Duran (2007).

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Appendix A

2005 Local Teams Cropland Soils and Marginal Pastureland

Rental Rate (in \$/acre/year) Review Summary⁵²

Addison and Chittenden, through which the Lewis Creek runs, are in bold.

Agricultural Value Groups (1 is the highest quality soil, 8 is the lowest)	1	2	3	4	5	6	7	8	Marginal Pasture Land
Addison	\$103	\$101	\$85	\$78	\$71	\$64	\$60	\$60	\$40
Bennington	\$103	\$101	\$85	\$78	\$71	\$64	\$60	\$60	\$48
Caledonia	\$101	\$85	\$78	\$71	\$64	\$60	\$54	\$47	\$40
Chittenden	\$121	\$111	\$102	\$93	\$81	\$74	\$67	\$62	\$49
Essex	\$101	\$85	\$78	\$71	\$64	\$60	\$54	\$47	\$40
Franklin	\$122	\$118	\$102	\$100	\$84	\$77	\$70	\$63	\$60
Grand Isle	\$122	\$118	\$102	\$100	\$84	\$77	\$70	\$63	\$60
Lamoille	\$100	(none)	\$84	\$82	\$82	\$82	\$48	\$48	\$48
Orange	\$120	\$110	\$102	\$90	\$80	\$75	\$70	\$60	\$46
Orleans	(none)	(none)	\$78	\$71	\$64	\$60	\$54	\$47	\$40
Rutland	\$103	\$101	\$85	\$78	\$71	\$64	\$60	\$60	\$48
Washington	\$121	\$111	\$102	\$93	\$81	\$74	\$67	\$62	\$49
Windham	\$122	\$118	\$102	\$100	\$84	\$77	\$70	\$63	\$65
Windsor	\$120	\$110	\$102	\$90	\$80	\$75	\$70	\$60	\$46

⁵² K. Peterson. VT CREP Soil Rental Rates. Ed. Lisa Gerstenberger. Vol. personal email, 2005.